

APPLICATION FOR UNITED STATES LETTERS PATENT

SPECIFICATION

(Case No. 98,627; 3Com No. 2036.CM.US.P)

5

Title: SYSTEM AND METHOD FOR INSURING DYNAMIC HOST
CONFIGURATION PROTOCOL OPERATION BY A HOST
CONNECTED TO A DATA NETWORK

10

Inventors: Ronald B. Lee, a citizen of the United States and a resident of Northbrook,
Illinois.

15

Assignee: 3Com Corporation
 5400 Bayfront Plaza
 Santa Clara, California 95052

092597-0329
06/22/98

SYSTEM AND METHOD FOR INSURING DYNAMIC HOST CONFIGURATION PROTOCOL OPERATION BY A HOST CONNECTED TO A DATA NETWORK

BACKGROUND OF THE INVENTION

5 A. Field of the Invention

The present invention relates to the field of network communications and, more particularly, with the configuration of network devices in a data network.

B. Description of Related Art

662220 25265260
Cable television service providers are taking advantage of the extensive reach of
10 the cable network infrastructure to offer high-speed data network access to users of
computing equipment, such as personal computers. Channels on the cable television
network may be allocated for use as data network access channels to exploit channel
bandwidths of 6 MHz on a medium having a frequency range of up to 1 GHz.

Subscribers of cable service may access data network services by connecting
15 computers to the cable network using cable modems. Subscribers may also access data
networks via one or more cable modems connected on a local area network. A cable
modem has a radio interface connection to a broadband coaxial cable infrastructure and a
data interface connection to the computer, or to a computer network. When used to
connect a computer to the cable network, the cable modem may operate internal to the
20 computer in a card slot with a direct connection to the bus system in the computer. The
cable modem may also operate external to the computer with an external connection (*e.g.*
Ethernet, serial, etc.) to the cable modem data interface.

Data networks connected to a cable network form what are called Data Over
Cable Systems. Data over cable systems use a device called a cable modem termination
25 system as an intermediary between a number of cable modems connected over the coaxial
communications medium and a data network. The data network may also include a
connection to the Internet. The cable modem termination system operates along with
other system components in a "head-end" of the cable network. A cable service provider
uses the cable modem termination system to distribute services to the cable modems

connected to it. The cable modem termination system also provides facilities that may be used to manage the resources available to the cable modems.

Cable modems may operate on a bi-directional cable system or on a uni-directional cable system. In a bi-directional cable system, the cable modems may communicate with the cable modem termination system over the coaxial medium in both directions. That is, the cable modems may transmit and receive data to and from the cable modem termination system over the coaxial medium.

In an uni-directional cable system, data is communicated over the coaxial medium in a "downstream" direction only. That is, the cable modem may only receive data from the head-end of the cable network over the coaxial medium. The cable modem may transmit data in the "upstream" direction to the head-end of the cable network using an alternative communications device; such as by a telephone connection over the public switched telephone network (PSTN). Because cable networks have been traditionally used as a broadcast medium for cable television, most data over cable systems are still uni-directional systems.

Uni-directional and bi-directional data over cable systems perform a procedure for configuring the cable modems to connect to a data network. The Dynamic Host Configuration Protocol (DHCP) is used by devices that are connected to networks, such as the Internet, to obtain configuration parameters and other information that make it possible for the devices to communicate on the Internet. The devices perform the DHCP protocol as clients that query a DHCP server during the initialization procedure performed by the device at boot up. Once the DHCP server responds with the appropriate parameters, the devices may begin to communicate by sending and receiving packets on the Internet. The DHCP may be used by client computers and by cable modems that are connected to a data over cable system.

The parameters that a device may obtain using the DHCP include an Internet Protocol address (IP address), a list of domain name servers, a domain name, the lease time of the IP address, a default gateway for the device, a trivial file transfer protocol (TFTP) server address and TFTP file name. The DHCP has been adopted by the industry as a standard protocol that is documented in RFC 2131. The RFC 2131 describes the

many parameters that may be obtained from the DHCP server. The RFC 2131 also describes instructions for communicating with the DHCP server. In a data over cable system, client computers and cable modems each use configuration parameters from a DHCP server before communicating on a data network. The cable modems obtain
5 parameters during the initialization and registration process. The client computers may also obtain configuration parameters during system initialization.

The client computer uses the cable modem to access the data network, and thus, to access the DHCP server. However, until the cable modem is properly initialized, registered and fully connected, it cannot perform communications functions for the client
10 computer or computers to which it is connected. This may cause problems for client computers in a variety of scenarios. For example, a computer may attempt to use a bi-directional cable modem to issue DHCP messages before the RF cable has been connected to the cable modem. In addition, if the cable modem and the computer are on the same power strip or if an internal cable modem is used and powered by the
15 computer's bus system, the two always power-up simultaneously. If it takes more time for the cable modem to power-up and to become initialized and registered than for the computers to perform DHCP messages, the DHCP messages will not be communicated. In such situations, the connection may become permanently shut down.

Moreover, any client computer that obtains configuration parameters from a DHCP server connected to a data network to which it accesses via a communications
20 device, such as a modem, or a gateway, may experience the same difficulty. If the communications device takes more time to initialize than it takes the client computer to begin requesting configuration parameters, the client computer may not be able to access configuration parameters from the DHCP server. Because a failure to retrieve
25 configuration parameters is typically treated as an error, the client computer may require a restart to begin another request for configuration parameters. Where the communications device is connected to the client computer system bus, the communications device is reset whenever the client computer is reset. The client computer may never obtain configuration parameters in such a scenario permanently
30 shutting down its connection to the data network.

It would be desirable to ensure DHCP operation on a client computer without the risk of permanently losing the connection through the communications device if the communications device is also not yet ready or able to perform DHCP messages from the client to the server.

- 5 It would be desirable to ensure DHCP operation on a client computer without the risk of losing the connection through the cable modem permanently if the cable modem is not yet ready or able to perform DHCP messages from the client to the server.

09259757-032799
662220-25265260

SUMMARY OF THE INVENTION

In view of the above, according to one aspect of the present invention an improved communication system comprising a customer premises equipment connected to a data network via a network connection is provided. The customer premises
5 equipment communicates with the data network when configured with a client network address. The customer premises equipment issues configuration messages to a configuration server connected to the data network to retrieve the client network address from the configuration server. The improvement includes a temporary configuration
10 server for responding to configuration messages from the customer premises equipment before the network connection is capable of connecting the customer premises equipment to the data network.

In a further aspect of the present invention, a cable modem is provided for providing a customer premises equipment with access to a configuration protocol server connected to a data network over a broadband coaxial cable medium. The data network
15 includes an interface to the broadband coaxial medium at a head-end of the broadband coaxial medium. The cable modem includes a cable input/output interface for communicably connecting the cable modem to the broadband coaxial cable medium. A data input/output interface is provided to communicably connect the cable modem to the customer premises equipment. A temporary configuration protocol server is included to
20 respond to configuration messages from the customer premises equipment before the cable modem is capable of connecting the customer premises equipment to the data network.

In a further aspect of the present invention, a method is provided for ensuring a connection to a configuration server on a data network by a customer premises
25 equipment. The customer premises equipment is connected to a network connection for interfacing to the data network. According to the method a request is issued for a customer premises equipment network address from the customer premises equipment to the configuration protocol server via the network connection. The network connection determines whether a connection can be made to the configuration protocol server. If not,

the network connection responds to the customer premises equipment by sending a temporary network address to the customer premises equipment.

09259767 022799
667220 76765260

BRIEF DESCRIPTION OF THE DRAWINGS

Presently preferred embodiments of the invention are described below in conjunction with the appended drawing FIGs., wherein like reference numerals refer to like elements in the various FIGs., and wherein:

5 FIG. 1 is a block diagram of a network of the type in which the present invention finds particular use;

 FIG. 2 is a block diagram of the network in FIG. 1 in a data over cable network system;

 FIG. 3 is a customer premises equipment that uses the DHCP to obtain
10 configuration parameters in the network shown in FIG. 1;

 FIG. 4A-E are block diagrams showing the status of the customer premises equipment and the flow of DHCP messages used during the negotiation of configuration parameters with the DHCP.

09259757.022799
66/220/25/25260

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The description that follows fully incorporates by reference the following co-pending patent applications: "METHOD AND SYSTEM FOR SECURE CABLE MODEM INITIALIZATION", U.S. Patent Ser. No. 09/018,756 to Nurettin B. Beser (filed February 4, 1998 and assigned to the assignee of the present invention);
"METHOD AND SYSTEM FOR SECURE CABLE MODEM REGISTRATION", U.S. Patent Ser. No. 09/018,372 to Nurettin B. Beser (filed May 14, 1998 and assigned to the assignee of the present invention); and "METHOD AND SYSTEM FOR CABLE MODEM INITIALIZATION USING DYNAMIC SERVERS", U.S. Patent Ser. No. 09/018,400 to Nurettin B. Beser (filed May 14, 1998).

FIG. 1 is a block diagram showing a system that may be used by a customer premises equipment **18a** to retrieve configuration parameters from a configuration server **50** for communicating over a data network **28**. The customer premises equipment **18a** communicates with the data network **28** over a network connection **13** as a host to the configuration server **50**. The network connection **13** may include a local network **14** over which the customer premises equipment communicates with other customer premises equipment **18b-d**. The network connection **13** may also include communications devices **15a-d** that connect corresponding customer premises equipment **18a-d** to the local network **14**. A network interconnection device **17** connects the local network **14** to the data network **28**.

The communications devices **15a-d** may include any device for communicably connecting the corresponding customer premises equipment **18a-d** to the local network **14**. A suitable communications device is selected according to the type of network used for the local network **14**. For example, the communications devices **15a-d** may include cable modems when the local network **14** is a cable network. For another example, the communications devices **15a-d** may include serial modems for when the local network **14** is a general switched telephone network. For yet another example, the communications devices **15a-d** may include network interface adapters when the local network **14** is a network communicating with ethernet, token ring, etc. The communications devices **15a-d** may also include a combination of devices, such as a telephony return cable modem

with a serial connection to the general switched telephone network and a coaxial connection for connection to the cable network. The communications devices **15a-d** may or may not require configuration parameters to enable communication between the customer premises equipment **18a-d** and the data network **28**.

5 The network interconnection device **17** may include any server, gateway, bridge, router or other type network device for connecting one network to another network. The network interconnection device **17** connects the local network **14** to the data network **28**. Appropriate protocol stacks are included in the network interconnection device **17** to ensure that the local network **14** can communicate with the data network **28**. One
10 protocol included in such protocol stacks may include a configuration protocol to permit the network interconnection device **17** to retrieve configuration parameters from the configuration server **50**.

662220 2526260
15 The network interconnection device **17**, the local network **14** and the communications devices **15a-d** provide the customer premises equipment **18a-d** with the network connection **13** to the data network **28**. Selected network communications protocols are performed by the components of the network connection **13** and the customer premises equipment **18a-d** to provide extensive connectivity and functional capability. Specific embodiments of the network connection **13** exist and depend on the types of networks implemented for the local network **14** and the communications devices
20 **15a-d**. In one embodiment, the local network **14** is a cable network and the communications devices **15a-d** are cable modems that provide the customer premises equipment **18a-d** with access to the data network **28** through the cable network. The cable network may be bi-directional or uni-directional. In the uni-directional network, the local network **14** may include a general switched telephone network and the cable
25 network.

In an alternative embodiment, the local network **14** may comprise an ethernet network, or other network type such as a token ring, a Universal Serial Bus, etc. The communications devices **15a-d** include appropriate network adapters for communicating over the local network **14**. The network adapters may be installed in a chassis for a bus
30 system in the customer premises equipment **18a-d**. The network interconnection device

17 includes a data over cable system in which a cable modem is communicably connected to the local network 14. The cable modem provides all of the customer premises equipment 18a-d with shared access to the data network 28. The cable modem in the network interconnection device 17 is connected to a cable network. The cable network is connected to a cable modem termination system, which provides the cable modem with access to the data network 28. The cable modem in such an embodiment may require configuration parameters from the configuration server 50.

The customer premises equipment 18a-d may include any type of computer, or device that uses computing resources, that may communicate with the data network 28. The customer premises equipment 18a-d are clients of the configuration server 50 from which it retrieves configuration parameters during initialization. The customer premises equipment 18a-d use the configuration parameters to communicate over the data network 28. Such parameters may include network addresses without which the communication over the data network 28 beyond broadcast searches for a server may not be possible.

The data network 28 in a preferred embodiment is connected to the Internet. The configuration server 50 in a preferred embodiment is the dynamic host configuration protocol (DHCP) server. One of ordinary skill in the art will appreciate that any data network 28 and any configuration server 50 operable to perform a configuration protocol that is compatible with the data network 28 may be used.

Embodiments of the present invention advantageously permit the customer premises equipment 18a-d to initialize in cases in which an operable network connection to the configuration server 50 may be unavailable. In a preferred embodiment, a temporary configuration server operates in the communications device 15a or in the network interconnection device 17 to provide temporary configuration parameters to the customer premises equipment 18. The configuration parameters are provided with a mechanism for requiring further requests for configuration parameters at a later time. For example, in a preferred embodiment, the temporary configuration parameters are provided with a lease time. Upon expiration of the lease time, the customer premises equipment 18 is required to make another request for configuration parameters. At this time, the temporary configuration server determines if an operable connection to the

configuration server 50 is possible. If it is not, the configuration server provides the same configuration parameters and lease time. If the connection is available, the temporary configuration server permits the request to be communicated to the configuration server 50.

5 A data over cable network system is one example of a network in which embodiments of the present invention may find advantageous use. FIG. 2 is a block diagram showing a data over cable network 10. It is to be understood by one of skill in the art that the data over cable network 10 is described as an example. The data over cable system used in the present invention may be configured in other ways not shown
10 here.

Most cable providers known in the art predominately provide uni-directional cable systems, supporting only a "downstream" data path. A downstream data path is the flow of data from a cable television network "headend" to customer premise equipment (e.g., a customer's personal computer). A cable television network headend is a central location
15 that is responsible for sending cable signals in a downstream direction. A return path via a telephony network ("telephony return") is typically used for an "upstream" data path in uni-directional cable systems. An upstream data path is the flow of data from customer premise equipment back to the cable television network headend.

However, data-over-cable system 10 may also provide a bi-directional data path
20 (i.e., both downstream and upstream) without telephony return as is also illustrated in FIG. 2. In a data-over cable system without telephony return, customer premise equipment or cable modem has an upstream connection to the cable modem termination system via a cable television connection, a wireless connection, a satellite connection, or a connection via other technologies to send data upstream to the cable modem
25 termination system.

The data over cable network 10 provides network access for a customer premises equipment (CPE) 18 via a cable modem network 14. The cable modem network 14 is connected to a data network 28 (e.g., an Internet subnet, an intranet, or any network that uses the transport control protocol/Internet protocol (TCP/IP)) by a cable modem
30 termination system 12. The CPEs 18 may include DHCP clients for retrieving

configuration parameters from a DHCP server 50. The CPE 18 may also retrieve configuration files from a trivial file transfer protocol server 51.

The CPE 18 in the network 10 of FIG. 2 may be a personal computer or workstation that uses the Windows NT, Windows 95 or later versions of Windows as an operating system. It is to be understood that any CPE using any operating system may be used in the CPE 18. The CPE 18 may include architecture for interfacing to communication devices. Such architecture advantageously standardizes communications interfaces and reduces the development time of application that uses communications interfaces.

The CPE 18 includes a cable modem to CPE connection 19, a cable modem-CPE interface (CMCI) 20, and a cable modem (CM) 16. The cable modem to CPE connection 19 may include a connection to the CPE bus if the cable modem 16 is implemented on a card, or circuit board, that plugs into the CPE bus structure. Alternatively, the cable modem 16 may be physically external to the CPE and connected by the cable modem to CPE connection 19 using an Ethernet network, token ring network, a serial connection, or any other suitable hardware connection.

The cable modem-CPE interface 20 includes the Windows Network Architecture and any drivers for controlling the hardware interface of the cable modem 16. The cable modem-CPE interface 20 includes any hardware drivers, protocol drivers and other hardware and software used to communicate with the cable modem 16.

In a uni-directional system, the cable modem 16 is connected to the cable modem network 14 which may include cable television networks such as those provided by Comcast Cable Communications Inc. of Philadelphia, Pennsylvania, Cox Communications, of Atlanta, Georgia, Tele-Communications, Inc. of Englewood, Colorado, Time-Warner Cable, of Marietta, Georgia, Continental Cable Vision, Inc. of Boston, Massachusetts and others.

The cable modem 16 is connected to a Public Switched Telephone Network ("PSTN") 22 with an upstream telephony connection. The PSTN 22 includes those public switched telephone networks provided by AT&T, Regional Bell Operating Companies (e.g., Ameritech, U.S. West, Bell Atlantic, Southern Bell Communications,

Bell South, NYNEX, and Pacific Telesis Group), GTE, and others. The upstream telephony connection is any of a standard telephone line connection, Integrated Services Digital Network ("ISDN") connection, Asymmetric Digital Subscriber Line ("ADSL") connection, or other telephony connection. The PSTN 22 is connected to a Telephony Remote Access Concentrator ("TRAC") 24.

In a data-over cable system without telephony return, the cable modem 16 has an upstream connection to CMTS 12 via the cable network 14, a wireless connection, a satellite connection, or a connection via other technologies to send data upstream outside of the telephony return path. An upstream cable television connection via cable network 14 is illustrated in FIG. 2.

The cable modem 16 includes cable modems provided by the 3Com Corporation of Santa Clara, California and others. The cable modem 16 may also include functionality to connect only to the cable network 14 and receives downstream signals from cable network 14 and sends upstream signals to cable network 14 without telephony return. The present invention is not limited to cable modems used with telephony return.

The cable modem 16 in FIG. 2 includes a computing platform that controls the communications functions performed by the cable modem 16. For example, the cable modem 16 may implement a variety of communications protocols. To implement one such protocol, the DHCP, the cable modem 16 includes a DHCP client for sending requests for configuration parameters to the DHCP server 50. Once the cable modem 16 receives configuration parameters, the CPE 18 can use the cable modem 16 to communicate with the data network 28.

In preferred embodiments of the present invention, the cable modem 16 also includes a temporary DHCP server for responding to DHCP requests from the CPE 18 while the cable modem 16 is in the process of connecting to the data network. Until the cable modem 16 is initialized including being assigned an IP address, it cannot communicate over the data network. Until the cable modem 16 is able to communicate over the data network 38, the CPE 18 is unable to request DHCP configuration parameters. In a preferred embodiment, the temporary DHCP server determines if the cable modem 16 is able to communicate over the data network 28. If the CPE 18 requests

configuration parameters using DHCP and the cable modem 16 is unable to communicate over the data network 28, the temporary DHCP server replies with a temporary IP address. The temporary DHCP server may also provide a selected lease time to the CPE 18. The lease time insures that the CPE 18 will continue to request the IP address. The temporary DHCP server senses when the cable modem 16 is able to communicate over the data network 28 and responds to future requests for the IP address with a DHCP NACK message. The CPE 18 then makes a DHCP DISCOVER, which the cable modem 16 communicates to a DHCP server in the data network 28 instead of to the temporary DHCP server.

The cable modem 16 provides the CPE 18 with connectivity to the data network 28 via the CMTS 12 and the TRAC 24. The CMTS 12 and TRAC 24 may be at a "headend" of the cable system 10, or TRAC 24 may be located elsewhere and have routing associations to CMTS 12. The CMTS 12 and TRAC 24 together are called a "Telephony Return Termination System" ("TRTS") 26. The TRTS 26 is illustrated by a dashed box in FIG. 2. The CMTS 12 and TRAC 24 make up TRTS 26 whether or not they are located at the headend of cable network 14, and TRAC 24 may in located in a different geographic location from CMTS 12. Content servers, operations servers, administrative servers and maintenance servers, shown as servers 31, may be used in data-over-cable system 10. The servers 31 may be in various locations.

Access points to data-over-cable system 10 are connected to one or more CMTS's 12 or cable headend access points. Such configurations may be "one-to-one", "one-to-many," or "many-to-many," and may be interconnected to other Local Area Networks ("LANs") or Wide Area Networks ("WANs").

The TRAC 24 is connected to the data network 28 by a TRAC-Network System Interface 30 ("TRAC-NSI"). The CMTS 12 is connected to data network 28 by a CMTS-Network System Interface ("CMTS-NSI") 32. The present invention is not limited to data-over-cable system 10 illustrated in FIG. 2, and more or fewer components, connections and interfaces could also be used. In addition, the present invention may include any type of network that uses the DHCP server for configuration parameters and that runs using any operating system.

66220-02799

The DHCP server **50** and the TFTP server **51** may operate on any computer that is accessible to the cable modem **16** over the data network **28**. Alternatively, the DHCP server **50** may be accessible over a local area network. The DHCP server **50** and the TFTP server **51** will provide configuration services for any DHCP client that may connect to it over the data network **28**. For example, in the cable system **10** shown in FIG. 2, the DHCP server **50** may provide configuration services for the cable modem **16**, any other cable modem connected to the cable network **14** and/or any network device connected to the data network **28**.

FIG. 3 is a block diagram of the CPE **18** showing the CPE to cable modem interface **20** according to a preferred embodiment of present invention. The CPE **18** in FIG. 3 uses the cable modem **16** to connect to the data network **28**. The CPE **18** is preferably a computing platform functioning as a workstation, personal computer, server or other computing system that may connect to the data network **28**. The CPE **18** includes a system initialization procedure **80**, a DHCP client **100**, and an Internet protocol (IP) stack **120**. The CPE **18** and the cable modem **16** retrieve configuration parameters from the DHCP server **50**.

The system initialization procedure **80** is performed on power-up or on any other re-initialization of the CPE system. One function of the system initialization procedure **80** is to initialize the hardware drivers used by the CPE to perform communications functions. With regards to communication over the data network **28**, the CPE **18** initializes a driver for the cable modem **16** (described below) and attempts to broadcast requests for configuration parameters. The CPE **18** requests configuration parameters from the DHCP server **50** over the data network **28** using one or more DHCP DISCOVER messages. When replies to the DHCP DISCOVER messages are received, the CPE **18** stores the configuration parameters in a memory space for client configuration parameters **194a, b**.

The DHCP client **100** performs DHCP operations for the CPE **18**. The DHCP DISCOVER message and messages sent in response to DHCP parameter negotiation (e.g. DHCP REQUEST, DHCP OFFER, etc.). The DHCP client **100** may also sense when the lease time for an IP address has expired, or may respond with a request to renew the IP

address by issuing a DHCP RENEW message. The operation of the DHCP client 100 is preferably in conformance with the provisions of RFC 2131.

The DHCP server 50, as shown in FIG. 3, provides a client IP address 196a to the CPE 18, and a cable modem IP address 196b to the cable modem 16. Although one
5 DHCP server 50 is shown in FIG. 3, one of ordinary skill in the art will appreciate that DHCP messages may be handled by different DHCP servers, or by selected DHCP servers. The operation of the DHCP server 50 is preferably in conformance with the provisions of RFC 2131.

The IP stack 120 includes protocol drivers conforming to selected protocols for
10 communicating with the data network 28 and to any other network to which a data connection is desired (*i.e.* the Internet). The protocols performed by the IP stack 120 may include the Universal Datagram Protocol (UDP), the Internet Protocol (IP), the transport control protocol (TCP), the point-to-point protocol (PPP), and any other protocol required for selected data network connections. The protocols selected for the IP stack 120
15 include a protocol having driver calls software that communicates to the cable modem 16 in the CPE to cable modem interface 20.

The CPE to cable modem interface 20 includes a cable modem driver 160 and the hardware and software components used to connect the cable modem 16 to the CPE 18.
20 Such components may include the bus or other type of interconnect system and the drivers that control communications on the bus system. For example, the cable modem 16 may be implemented on a PCMCIA (Personal Computer Memory Card International Association) card that interfaces with the CPE 18 using the PCMCIA bus system. The cable modem 16 may also be implemented as an external device connected to the CPE 18
25 by an Ethernet-based local area network. The cable modem 16 may also be implemented on a card in a second CPE or server that is connected to the CPE 18 and used by the CPE 18 for access to the data network 28. In a preferred embodiment, the connections between the IP stack 120, the cable modem driver 160 and the cable modem 16 substantially conform to the Open System Interconnection ("OSI") model used to describe computer
30 networks. Reference is made to the Multimedia Cable Network Systems ("MCNS")

1662220 45465260

Data-Over-Cable Service Interface Specifications, Radio Frequency Interface Specification, SP-RFI-102-971008, (hereinafter "MCNS standard), which is incorporated herein by reference, for implementing the IP stack 120, the cable modem driver 160 and the cable modem 16 according to a preferred embodiment. The cable modem driver 160
5 executes communications commands for using the cable modem 16 to communicate over the cable network 14 to other devices on the data network, such as the DHCP server 50. In a Microsoft Windows operating system environment, the cable modem driver 160 may be developed using the Network Driver Interface Specification (NDIS) in the Windows Network Architecture. The Windows Network Architecture also includes libraries of
10 function calls to protocol drivers, which are programs for executing the protocol performed by the IP stack 120. The protocol drivers may be accessed using the Transport Driver Interface (TDI) which is also known as a Windows socket. Information regarding the Windows Network Architecture or any other Windows programming resource may be found in the Microsoft Windows 95 Resource Kit published by the Microsoft Press by the
15 Microsoft Corporation.

Drivers, such as the cable modem driver 160 in a preferred embodiment, that are developed using standard development tools, such as the NDIS in Windows, typically require a uniform set of parameters defined by a standard interface. The parameters include an IP address and other parameters that may be retrieved from the DHCP server
20 50.

The cable modem 16 in FIG. 3 includes hardware and software components for interfacing a data communications system (such as the CPE 18) to the coaxial communications medium. In a preferred embodiment, the components include a DHCP server 140, a data I/O interface 170, a cable modem processing system 176, a cable I/O
25 interface 172, and a DHCP client 190. In the description that follows, the cable modem 16 in FIG. 3 is assumed to be a bi-directional cable modem. One of ordinary skill in the art will appreciate that preferred embodiments of the present invention may be carried out in a uni-directional system with the appropriate modifications, which are un-important to the present invention.

092597.0229

The data I/O interface **170** includes the hardware and software components for communicating with the CPE **18**, which may include functions performed according to the protocols described above. The cable modem **16** may receive communications from the CPE **18** at the data I/O interface **170**. The cable modem **16** may also send
5 communications to the CPE **18** via the data I/O interface **170**. In an internal cable modem **16**, the data I/O interface **170** may include a PCI bus adapter and associated hardware drivers. In an external cable modem **16**, the data I/O interface **170** may include an Ethernet, USB, or token ring adapter and associated drivers. It is to be understood by one of ordinary skill in the art that other components may be used in the data I/O
10 interface **170**.

The cable I/O interface **172** includes an RF interface and other hardware and software components for modulating and demodulating the RF signal and for communicating data to and from the RF interface **161**. For examples of the cable I/O interface **172** according to a preferred embodiment, reference is made to the MCNS
15 standard. Alternative embodiments may implement an RF interface as described in the IEEE ("Institute for Electrical and Electronic Engineers") standard 802.14 for cable modems.

The cable modem processing system **176** provides processing resources for the cable modem **16**. Such resources include a central processor, memory and input/output control. The cable modem processing system **176** also includes an operating system that performs an initialization process. During the initialization process, the cable modem **16**
20 performs initialization and registration functions by communicating initialization and registration messages to and from the headend **26** of the cable network **14**. Included in these functions is the retrieval of configuration parameters from the DHCP server **50**.

25 The cable modem DHCP client **190** performs the DHCP client functions for retrieving configuration parameters such as the IP address. The cable modem DHCP client **190** issues DHCP DISCOVER messages to obtain a cable modem IP address **192a** and other configuration parameters **192b**.

In a preferred embodiment of the present invention, the cable modem **16** includes
30 a temporary DHCP server **140**. The temporary DHCP server **140** is able to detect

whether the cable modem 16 has established a connection for communication with the headend 26. If the cable modem 16 has yet to achieve a connection, the temporary DHCP server 140 responds to DHCP DISCOVER messages from the CPE 18 with a DHCP OFFER. The DHCP OFFER sent by the temporary DHCP server 140 includes a client temporary IP address 142a and a lease time 142b. Until the temporary DHCP server 140 senses that the cable modem 16 is fully connected, initialized and registered, it acknowledges requests to renew the temporary IP address 142a.

The temporary IP address 142a is preferably an IP address that has been reserved for this use, however, it may be any IP address that may be recognized by the cable modem 16 as being a temporary one. The temporary IP address 142a is maintained private to the CPE 18 or to other CPE's that may be connected to the cable modem 16. The temporary IP address 142a is not used for connectivity to any network. The cable modem 16 filters out any attempt to communicate using the temporary IP address 142a.

The CPE 18 is shown in FIG. 3 connected to the cable modem 16 which connects the CPE 18 to the data network 28. In an alternative embodiment, the cable modem 16 may provide communicative connectivity for other CPE's (see FIG. 1). In such an embodiment, the temporary DHCP server 140 includes a pool of temporary IP addresses 142a.

In addition, the lease time 142b may be set to a short enough length of time to make the use of the temporary IP address 142a unlikely. The lease time 142b is preferably from 5 to 10 seconds, however, shorter or longer lease times are possible. Because the cable modem 16 may require one or more minutes to achieve connectivity, the lease time 142b may expire, and the temporary IP address 142a may be renewed many times before the cable modem 16 has connectivity.

In a uni-directional system, the cable modem 16 communicates upstream on a telephony link. The dialing of the telephone to initiate the link may not occur at boot up and may even require other events to trigger it. As a result, the time it takes for the cable modem 16 to achieve connectivity may vary greatly, and may be indeterminate.

Once the cable modem 16 has achieved connectivity with the headend 26, the temporary DHCP server 140 responds to any further requests to renew the temporary IP

address **142a** with a message that does not acknowledge the request. The message that does not acknowledge the request to renew prompts the DHCP client **100** in the CPE **18** to issue a DHCP DISCOVER message to retrieve a new IP address. Because the cable modem **16** has established connectivity, the DHCP DISCOVER message is broadcast
5 through the headend **26**. The DHCP server **50** responds with a DHCP OFFER. The DHCP server **50** may be the first DHCP server to send a DHCP OFFER, or it may be the one that offers an acceptable set of configuration parameters.

The temporary DHCP server **140** in the cable modem **16** advantageously permits the CPE **18** to "wait" for a legitimate IP address and other configuration parameters when
10 the cable modem **16** is unable to communicate with the headend **26**.

FIGs. 4A-4E are block diagrams showing the message flow of DHCP messages issued by the CPE **18** and the cable modem **16** in the system shown in FIG. 2. FIGs. 4A-4E are described below as events that occur during a simultaneous re-boot of the CPE **18** and of the cable modem **16**. One of ordinary skill in the art will appreciate, however, that
15 the process illustrated by FIGs. 4A-4E advantageously insures DHCP connectivity by the CPE **18** in any situation in which it is sought before the cable modem **16** has achieved connectivity with the data network **28**.

Referring to FIG. 4A, during the initialization of the cable modem driver **160** (shown in FIG. 3), the DHCP client **100** in the CPE **18** issues a DHCP DISCOVER
20 message **200a**. The DHCP DISCOVER message **200a** is communicated to the cable modem **16** for transmission to the data network **28**. The DHCP DISCOVER message **200a** is issued for the purpose of discovering the DHCP server **50** connected to the data network **28** that will provide the CPE **18** with an IP address. The cable modem **16** is also initializing and as part of its initialization, it issues a cable modem DHCP DISCOVER
25 message **202a** to retrieve a cable modem IP address. As shown in FIG. 4A, the cable modem configuration parameters does not yet have the cable modem IP address **192a** and the other configuration parameters **192b**.

The cable modem driver **16** receives the CPE DHCP DISCOVER message **200a**. Because the cable modem **16** has not achieved connectivity with the data network **28**, the
30 temporary DHCP server **140** receives the CPE DHCP DISCOVER message at **200b**. The

temporary DHCP server **140** includes the client temporary IP address **142a** and the lease time **142b**. The temporary DHCP server **140** responds by configuring a DHCP OFFER message **200c** for transmission by the cable modem driver **16** to the DHCP client **100** over **200d**. The DHCP OFFER message includes the temporary IP address and the lease time.

The DHCP client **100** receives the DHCP OFFER at **200d** and issues a DHCP REQUEST to accept the configuration parameters. The DHCP server **50** responds with a DHCP ACKNOWLEDGE. When the DHCP client **100** receives the DHCP ACKNOWLEDGE, the DHCP client **100** sets the configuration parameters for the CPE **18** at **200e**. The CPE IP address **194a** is set to the temporary IP address and the other configuration parameters **194b** includes the lease time. The temporary IP address **142a** received by the CPE **18** may not be used for communication over the data network **28** since it was not assigned by the DHCP server **50**. The cable modem **16** preferably filters any attempts by the CPE **18** to use the temporary IP address **142a**.

Referring to FIG. 4B, the time that the lease time provides for the assignment of the temporary IP address **142a** to the CPE **18** may expire many times before the cable modem **16** is able to connect to the data network **28**. Each time the lease time expires, the DHCP client **100** sends a request to renew the temporary IP address **142a** at **204a** in FIG. 4B. The cable modem **16** sends the request to the temporary DHCP server **140**, which determines whether the cable modem **16** has achieved connectivity with the data network **28**. If the cable modem **16** has not achieved connectivity with the data network **28**, the temporary DHCP server **140** sends a DHCP ACK message at **204c**. The DHCP client **100** receives the DHCP ACK message at **204d** and re-assigns the temporary IP address at **204e** with the lease time. The request to renew process shown in FIG. 4B may be repeated many times before a permanent IP address can be assigned to the CPE **18**.

Referring to FIG. 4C, in response to the DHCP DISCOVER message **202a** in FIG. 4A, the cable modem **16** receives a DHCP OFFER from the DHCP server **50** at **202b**. The DHCP OFFER message includes a cable modem IP address and other configuration parameters used by the cable modem **16** to communicate over the data network **28**. The cable modem **16** sets the cable modem IP address **192a** and the other

configuration parameters **192b** in a configuration parameter table. Once the cable modem **16** has received the cable modem IP address **192a** and its other configuration parameters **192b**, it may complete its initialization and registration process to achieve connectivity to the data network **28**.

Referring to FIG. 4D, although the cable modem **16** has achieved connectivity with the data network **28**, the DHCP client **100** in the CPE **18** continues to attempt to renew its temporary IP address **194a** at **204a**. The temporary DHCP server **140** receives the request at **206a**. Because the cable modem **16** has achieved connectivity with the data network **28** and therefore, access to the DHCP server **50**, the temporary DHCP server **140** denies the request using a DHCP NACK message at **206b**. The DHCP client **100** receives the DHCP NACK message at **206c** and determines that it no longer has a valid IP address.

Referring to FIG. 4E, the DHCP client **100** in the CPE **18**, sends a DHCP DISCOVER message at **200a** to obtain a new IP address. The cable modem **16** receives the message and transmits the message at **208a** over the data network **28**. The DHCP server **50** responds to the DHCP DISCOVER message at **208b** with a DHCP OFFER message containing a legitimate CPE IP address from its database of IP addresses **196**. The cable modem **16** sends the DHCP OFFER to the DHCP client **100** at **208c**. The DHCP client **100** issues a DHCP REQUEST to accept the configuration parameters. The DHCP server **50** responds with a DHCP ACKNOWLEDGE. When the DHCP client **100** receives the DHCP ACKNOWLEDGE, the DHCP client **100** assigns the configuration parameters including the CPE IP address at **208d**.

In a preferred embodiment, the parameters that the DHCP client **100** may receive include:

- IP address
- default gateway
- subnet mask
- domain name
- domain name server
- lease time

- binding time
- renewal time
- tftp filename
- tftp server address

5 These configuration parameters are described in RFC 2131. In a preferred embodiment, the lease time that may be provided in the DHCP OFFER message in FIG. 4E is longer than the lease time provided in the DHCP OFFER message in FIG. 4A.

While the invention has been described in conjunction with presently preferred embodiments of the invention, persons of skill in the art will appreciate that variations
10 may be made without departure from the scope and spirit of the invention. For example, the use of the protocols, tools, operating systems and standards referenced above is merely by way of example. Any suitable protocol, tool, operating system or standard may be used in preferred embodiments of the present invention. In addition, the methods described in FIGs 4A-4E are described in the context of a data over cable system.
15 However, the temporary configuration server may operate in any network connection that provides access to the data network 28. This true scope and spirit is defined by the appended claims, interpreted in light of the foregoing.